Scientia Horticulturae 178 (2014) 43–54

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Review

Changes in vineyard establishment and canopy management urged by earlier climate-related grape ripening: A review

Alberto Palliotti[a,*], Sergio Tombesi[a], Oriana Silvestroni[b], Vania Lanari[b], Matteo Gatti[c], Stefano Poni[c]

[a] Dipartimento di Scienze Agrarie, Alimentari ed Ambientali, Università di Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy
[b] Dipartimento di Scienze Agrarie, Alimentari ed Ambientali, Università Politecnica delle Marche, Via Brecce Bianche, 60131 Ancona, Italy
[c] Istituto di Frutti-viticoltura, Università Cattolica del Sacro Cuore, Via Emilia Parmense 84, 29122 Piacenza, Italy

ARTICLE INFO

Article history:
Received 17 June 2014
Received in revised form 28 July 2014
Accepted 29 July 2014
Available online 27 August 2014

Keywords:
Summer pruning
Source-sink balance
Sugar accumulation rate
Mitigation
Antitranspirant
Plant growth regulators

ABSTRACT

One of the main objectives of wine grape growers in several viticultural areas throughout history has been the achievement of full ripening, i.e. maximum soluble solids concentration in the absence of apparent berry shrinkage. Recently, this target is somewhat losing its appeal since an increasing number of consumers from both domestic and foreign markets prefer lighter wines characterized by moderate alcohol content. The above scenario needs to be added of another actor, i.e. the global warming and its effects on vine growth and berry composition which can be summarized as it follows: (i) onset of flowering and veraison phenological stages occurs earlier; (ii) grape ripening is generally accelerated as per increment of sugar accumulation into the berries which, in turn, leads to higher alcohol content in the wine; (iii) faster depletion of organic acids in the juice and more rapid increase of pH values which, as a consequence, triggers high microbiological instability of the must during pre-fermentation; (iv) due to excessive heat summations and poor thermal excursion the overall aroma profile can result untypical shifting towards overripe; (v) uncoupling of technological (more accelerated) and phenolic (more delayed) ripening with negative effects on grape and wine aroma and flavor, especially in red grape varieties; (vi) higher frequency of berry withering up to sun burn damage. In the medium-to-long term these factors likely will affect the geographical distribution of viticulture and will require new breeding programs for selecting more adapted roostocks and scions, whereas in the short term, new management techniques able to mitigate these negative impacts are urgently needed. In this review, several tools including varietal and clonal choice, possible diversification of wines produced, suitable training system and rootstocks, traditional and innovative management techniques able to regulate a too much accelerated and/or unbalanced grape ripening process, will be presented and discussed.

Contents

* Corresponding author. Tel.: +39 075 5856258; fax: +39 075 5856255.
E-mail address: alberto.palliotti@unipg.it (A. Palliotti).

http://dx.doi.org/10.1016/j.scienta.2014.07.039
0304-4238/

1. Introduction

Wine is etymologically defined as *an alcoholic drink beverage made from the fermentation of grape juice* (Oxford dictionary). Lawfully, the wine is instead defined in terms of different minimum and maximum alcoholic strengths according to countries. Thus, in all European Union countries and in Switzerland the lower and upper alcohol limit are established at 8.5% and 15% vol., respectively, with some exceptions (CE regulation n. 479/2008, art. 1 c and DFI 29/11/2013 art. 4); in South Africa table wine is required to contain less than 16.5% vol. alcohol and at least 6.5% vol. (South African Government 1990), while in USA the Federal Alcohol Administration Act established that the wine must have an alcohol content between 7% and 24% vol.

Traditionally, a general desirable target of wine grape growing worldwide has been to achieve high total soluble solids (TSS) (Kliewer and Weaver, 1971; Jackson and Lombard, 1993) since this parameter is the benchmark for the price-point of the grapes in several countries (Koblet, 1986). Today, though, this target is somewhat losing its appeal since an increasing number of consumers from both domestic and foreign markets prefers wines with moderate alcohol content (Salamon, 2006; Seccia and Maggi, 2011), which can naturally be obtained in vineyards through the reduction of TSS accumulated into the grapes. This new trend is also linked to the negative effects of the alcohol on human health and the more severe controls on vehicle drivers worldwide, as well as to significant changes in people life style and to organoleptic relishes requested in modern wines, such as freshness and tastiness. Ethanol can enhance the perception of sweetness and bitterness while reducing that of acid, saltiness and sourness (Martin and Pangborn, 1970; Fisher and Noble, 1994). Moreover, high alcohol content can negatively affect malolactic fermentation because *Oenococcus oeni* cells lose membrane stability, which, in turn, leads to a delay in wine stabilisation and ageing and an increase in undesirable sensory modifications (Graca da Silveira et al., 2002). High grape TSS concentration has also significant impact on the fermentation process and subsequent wine composition including changes in both sensory characteristics and in microbiological activity, linked mainly to growth inhibition or lysis of yeast cells, as well as sluggish and stuck fermentations. These latter phenomena are aggravated in hot years (Coulter et al., 2008) with a negative impact on wine composition. Lastly, high TSS stress was found to up-regulate glycolytic and pentose phosphate pathway genes (Erasmus et al., 2003) leading to the formation of undesirable by-products of fermentation, such as acetic acid and glycerol (Pigeau and Inglis, 2005).

The limitation of grape TSS concentration in the vineyard is also useful to minimize costly interventions in the winery aimed at dealcoholize the wines such as membrane techniques, supercritical fluid extraction and vacuum distillation. These physical techniques have recently become legal in the European Union (Council Regulation n. 606/2009) with a maximum alcohol reduction of 2% vol. Moreover, a major drawback of a too fast TSS development is that in several viticulture areas this process occurs during the hottest part of the season (Jones et al., 2005; Webb et al., 2012), when both color and aroma profile can be adversely affected (Lacey et al., 1991; Reynolds and Wardle, 1993; Mori et al., 2007). Under these conditions, grapes often combine an excessively low acidity and high pH, thus requiring the addition of tartaric acid before fermentation in order to avoid microbiological instability and improve mouth feel (Keller, 2010).

Over the last two decades a trend toward overly fast grape ripening with excessive TSS accumulation in the fruit and high alcohol in the resulting wine emerged in several countries (Duchene and Schneider, 2005; Godden and Gishen, 2005; Dokoozlian, 2009; Chaves et al., 2010; De Orduña, 2010; Keller, 2010; Jones, 2012). In many cases, irrespective of grape cultivar, such features matched with unacceptably low acidity, high pH and atypical flavors in the grapes (Keller, 2010). Webb et al. (2012) reported that in Australia wine grapes have undergone earlier ripening in recent years and, by using 64 years series, indicated that warming and reduction in soil water content are driving a major portion of this ripening trend.

Excessive TSS accumulation has been linked to several factors: (i) global warming and a rise in canopy photosynthetic potential due to a steady increase of CO_2 concentration in the atmosphere (Schultz, 2000; Bindi et al., 2001; Ainsworth and Rogers, 2007); (ii) improvements in vineyard management; *(iii)* law-enforced yield constraints in several Appellation areas; (iv) adoption of grapevine cultivars characterised by low cluster weight and/or grafted on low-vigour rootstocks; and (v) improved sanitary status of the propagation material. In the medium-to-long term these factors will likely affect the geographical distribution of viticulture (Schultz, 2000; Jones et al., 2005; Keller, 2010; Caffarra and Eccel, 2011), whereas, in the short term, new management techniques able to mitigate these negative impacts are needed.

2. Future planning of viticulture according to global warming

The specific climate is crucial to the overall style of a wine produced from well-defined areas. The ability to reach complete grape maturation is fundamental in determining the best cultivar to be grown in a given climate and climate variability determines year-to-year differences in the grape and wine quality (Jones and Hellman, 2003). In particular, temperature and irradiance are critical because of their direct effect on the length of growing season, phenological stages, vine yield by means of flower and berry abscission, berry growth, and the synthesis and accumulation of sugars, organic acids, polyphenols, vitamins and aromatic compounds in the berries (Gladstone, 1992; Keller, 2010).

A steady trend of increasing warming is pushing traditional areas of grape growing toward accelerated ripening (Jones et al., 2005), leading, in turn, to excessive sugar accumulation in the fruit